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Newsletter

Canada
United States
Spruce Budworms
Program

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Bacillus thuringiensis

Bacillus thuringiensis (B.t.) is a sporeforming bacterium, which was first isolated in 1905 from dying silkworm, when the discoverers noted that larvae infected by old cultures of B.t. quickly became paralyzed and eventually died from a septicemia. In 1911, Berliner isolated the bacterium from *Anagasta kuhniella*, and in 1927 Mattes reisolated the organism. From then on the potential of B.t. in insect control was recognized and explored.

All sporeforming bacteria produce endospores, which are the resistant forms of the bacteria, that allow the species to persist in a dormant state outside the intended host. B.t. also produces a proteinaceous toxic crystal called the "parasporal body" within the vegetative cell and in close proximity to the spore. Although the significance of the crystal to the bacterium itself is still uncertain, its toxic effect on lepidopterous larvae has been well studied and its activity spectrum is known to be broad. When B.t. is cultured on artificial media, the vegetative cells eventually break down and release the spores and crystals into the media. This spore-crystal complex forms the basis of commercial formulations used today.

When this complex is ingested by susceptible Lepidoptera, the crystals dissolve in the midgut, causing damage to the gut and cessation of feeding. At the same time, the ingested spores germinate within the gut and eventually enter the hemocoel of the host where extensive multiplication takes place, contributing to death of the host by septicemia. Dissolution of the crystal requires high gut pH for greatest activity. Thus, insects with low gut pH are relatively insensitive to the disease. This partly explains differential susceptibility of insect species to B.t. infection. Some 150 lepidopterous species are susceptible to B.t.

Commercial B.t. is the preferred insecticide for a number of agricultural crop pests. It is presently being tested

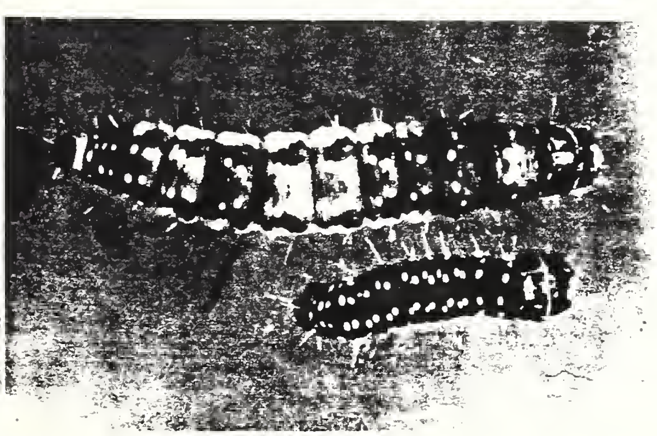

Figure 1 Healthy spruce budworm (top)
Spruce Budworm larva fed B.t. (bottom)
Note dark pigmentation and shrivelled appearance.

intensively, and extensively, for use against forest insect pests, many of which are highly sensitive to the bacterium (Table 1).

There are several factors that can affect or influence the effectiveness of B.t. applied to forest trees:

1. Susceptibility of the pest species — even within the most susceptible group (Lepidoptera), differential susceptibility can be very pronounced.
2. Environmental factors — sunlight, temperature, and antibiotic exudates from foliage can inactivate B.t. within 1-5 days, thus reducing potential effectiveness. Among pest species like the spruce budworm, which feed openly only intermittently, rapid inactivation of the pathogen tends to limit its effectiveness. There is a commercially available sunlight screen, "Shade", which at about 6 percent concentration has been reported to extend the life of B.t. in forest conditions.
3. Formulations used in the forest should have good physical properties, as well as sprayability, stickers and spreaders, anti-evaporants and UV protectants. The presently available commercial formulations do not fully meet these requirements.
4. Application technology is still underdeveloped, particularly in terms of spray nozzle systems, droplet spectra, dosage rate (volume), deposit analysis, aircraft type, and timing of application.
5. B.t. is presently a relatively expensive pest control agent. However, as forest resources increase in value, the cost-benefit ratio will become more and more favorable. Where chemical pesticides are prohibited in watershed and recreational forested areas, the cost-benefit for B.t. is already highly favorable.

Aside from the advantage of specificity for lepidopterous larvae already mentioned, perhaps the two most important benefits from the use of B.t. against forest insect pests relate to the phenomenon of pest resistance and the question of environmental safety.

Resistance of pests to chemical pesticides is not infrequent, and the possibility of pests acquiring resistance to disease agents is conceivable. For example, in England, laboratory populations of the cabbage butterfly (*Pieris brassicae*) constantly exposed to a granulosis virus apparently became resistant to the disease. However, there are no records so far of the resistance of insects to microbial agents in field trials or control programs. Also there are no indications as to the number of generations needed for an insect to develop resistance to B.t. Thus, the likelihood of pest insects developing resistance to B.t. in the foreseeable future is low indeed.

Recently the environmental safety of B.t. was questioned. The possibility of B.t. mutating in nature to a form pathogenic to mammals was raised, but such mutations are unlikely to occur since B.t. has existed in nature for eons and yet it has retained a relatively narrow host-range of approximately 150 species out of the 1 to 2 million species composing the insect world. Most genetic mutations result in loss of function rather

than the gain of a new one. B.t. has been tested without adverse effects against numerous invertebrate species in the families Porifera, Coelenterata, Platyhelminthes, Nematoda, Annelida, Orthropoda, and Mollusca. Safety has been substantiated for some 75 species of fish and birds, 40 species of beneficial arthropods and a variety of mammals including mice, rats, cattle, rabbits, sheep, dogs and man. There is no record of cumulative toxicity. B.t. has a zero tolerance registration because it has no demonstrable impact on nontarget organisms.

The use of B.t. for controlling economically important forest insect pests goes back to 1960 when Thuricide SO-75 was aerially applied against the spruce budworm in New Brunswick. Numerous field trials have taken place in Canada and the United States against this species with varying degrees of success, partly because the deposit efficiences of the water-based formulations tended to vary widely with changing meteorological conditions under which they were applied. Results of a 1979 series of cooperative trials sponsored by CANUSA suggest that oil-based formulations of B.t. may be more effective than water-based ones in terms of foliage protection. Comparative field research of the different formulations is warranted.

A variety of techniques are being explored to enhance the effectiveness of B.t. Several studies have suggested that the insecticidal effect of B.t. can be enhanced by simultaneously applying low concentrations of selected chemical pesticides, or the enzyme chitinase. However, these techniques have not yet advanced to the stage of general acceptance. Combinations of entomopathogenic viruses and B.t., or B.t. and other bacterial pathogens, have shown some promise in the laboratory but have produced conflicting results in field applications. The pathogens have been applied mixed or separately. There are logical reasons for applying such techniques in forest pest control, but a better understanding of host-pathogen relationships and pathogen interactions is needed before further field applications of such combinations of pathogens. Sequential applications of B.t. and entomogenous parasites are worth exploring.

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Aerial Application Simulation Tests Conducted In West

Two new spray systems, which simulate aerial application of candidate chemical and microbial insecticides for reducing populations of western spruce budworm, were field tested in 1979 on the Gallatin National Forest in Montana. The purpose was to provide predictive information on effective dosage rates of various candidate control materials. This information should make it possible to limit the selection of materials for expensive aerial testing to the most promising candidates and application rates.

Using the registered dosage of acephate as the test standard, both systems were evaluated for ability to simulate aerial application on small, naturally infested Douglas-fir and subalpine fir trees. Results showed both systems adequately simulated aerial application by causing a budworm population reduction equivalent to 90 percent. In addition, both spray systems produced a uniform insecticide deposit of 15-20 drops/cm^2.

Information was also gathered on the effectiveness of Bolstar, an organophosphate insecticide, and UC-51762, a carbamate insecticide, as well as several new formulations of *Bacillus thuringiensis* (B.t.), a microbial insecticide.

Bolstar caused a budworm population reduction of 86.2 percent at 22.4 g a.i./L (gram active ingredient per litre) and UC-51762 caused a reduction of 98 percent at 45 g.a.i./L, when delivered at a rate of approximately 4.6 L/ha (litres/hectare). Comparisons were made of six aqueous suspensions of two commercial B.t. products, Dipel(R) 4L and Thuricide 32B, applied at 8 B.I.U./gal/acre (20 B.I.U./9.35 L/ha). Budworm larval population reductions were increased from 37 percent to over 60 percent at 14 days after spraying by the addition of 25 percent molasses (v/v) or 25 percent Sutro(R) (a polyhedric alcohol) plus Shade(R) (a sunlight protectant) to the water. Dipel mixed in water, and in water plus 10 percent diesel oil, showed population reductions of 20 percent and 13 percent, respectively. Rainfall in the study area 48 hours after spraying may have adversely affected the effectiveness of the treatments.

These experiments successfully demonstrated the effectiveness of simulated aerial application as a useful bioassay tool which can provide valuable information on materials and dosage rates for large scale aerial tests. An additional advantage is that candidate control materials can be subjected to a more realistic field evaluation with less chemicals sprayed in the environment during testing.

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Milton J. Stelzer — Pacific Northwest Forest and Range Experiment Station, Corvallis, OR.

Table 1
A partial list of forest insect pests which are susceptible to *Bacillus thuringiensis* under field conditions

Insect Species	Common Name	Countries
Porthetria (Lymantria) dispar L	Gypsy moth	USA Yugoslavia Bulgaria Romania, Canada Germany
Choristoneura fumiferana (Clem.)	Spruce budworm	Canada USA
Choristoneura occidentalis (Freeman)	Western spruce budworm	Canada USA
Orgyia pseudotsugata McD	Douglas-fir Tussock moth	Canada USA
Malacosoma disstria Hubn	Forest tent caterpillar	USA, Canada
Malacosoma neustria	Forest tent caterpillar	Bulgaria Romania Germany
Paleacrita vernata (Peck)	Spring cankerworm	USA
Phryganidia californica Packard	California oakworm	USA
Acleris variana (Fern.)	Blackheaded budworm	Canada
Zeiraphera diniana (Gn.)	Larch budmoth	Switzerland France
Dendrolimus spp. Butler	Pine caterpillar	China USSR Germany
Thaumetopoea pityocampa Schiff	Pine processionary moth	Italy France Germany
Hyphantria cunea Drury	Fall webworm	Canada USA Hungary

ACAFA Spring Meeting

The National Research Council of Canada's Associate Committee on Agricultural and Forestry Aviation (ACAFA) held its annual meeting in early May 1980 in Fredericton, N.B. Sessions were just prior to the full-scale spruce budworm spraying operations. H.J. "Bud" Irving, Manager of Forest Protection Limited, acted as host. This was the first time that the Committee has met in Fredericton. The Chairman (W. Loftus) emphasized the importance placed on the budworm problem, and hoped that by scheduling the meeting in New Brunswick at the time of initiation of the treatment operation, the attention of the Committee would focus on the general concerns encountered in spruce budworm spray operations.

CANUSA Working Groups

The second annual Eastern CANUSA Working Group Meetings were held in Toronto during the week October 29-November 2, 1979. A brief synopsis of each of the eight groups follows:

1) **Environmental Impact Working Group**
Cochairmen: Terry May (University of Maine at Orono);
Peter Kingsbury (Forest Pest Management Institute)

This was probably the largest meeting with nearly 70 persons attending. It was agreed that research responsibilities of the group related primarily to registration of insecticides, monitoring and evaluation of short-term environmental impacts, and the determination of causes of long-term environmental effects.

Reports were given on the impact of the chemical insecticide, Matacil(R) which is used in Canada. Matacil is not yet registered in the U.S. The group determined that research priority should be given to improving monitoring techniques, evaluating impacts on ecological processes, and evaluating secondary effects on long-term changes in communities. Emphasis should be placed on changes in processes and communities rather than at the individual species level.

2) **Economics Working Group**
Cochairmen: Kenneth Runyon (Maritimes Forest Research Centre);
Dave Gansner (Northeastern Forest Experiment Station)

The group reviewed the CANUSA Program targets, projected accomplishments, and CFS goals. Reports were given on the economics of salvaging budworm-killed trees. It was felt that economics could not be set off as a separate entity but should be discussed in conjunction with other subjects under consideration.

The following guidelines for needs and priorities in economic research were determined. First, it is necessary to develop methods to identify the socioeconomic impact of growth reduction and tree mortality, as well as the effects of tree mortality on harvesting, transportation, processing costs and maintaining product quality. Second, methods to evaluate the economic effects of various management strategies must be developed as well as design of models of alternative strategies.

3) **Principal Outbreak Causes Working Group**
Cochairmen: Yvan Hardy (Laval University);
Harold Batzer (Northcentral Forest Experiment Station)

This was a large group with 50 people present. Projected accomplishments for the group were: hazard rating guides for pre-outbreak and outbreak conditions, and guides to identify forest conditions conducive to chronic spruce budworm populations. There was a feeling that much more biological "realism" is needed in understanding outbreaks than is present in current models. Three major areas of research were identified and are given in descending order of priority. Within each area are a number of topics.

Forest Factors: Includes the relationship between forest associations and spruce budworm outbreaks, insect-host plant relationships, and environmental factors.

Biological factors: Included are the "predator pit" (after Holling's low population natural control factors) and population genetics.

Insect behavioral factors: This included moth and larval dispersal and the somewhat hypothetical "pheromone pit."

Two areas of potential Canadian-U.S. research cooperation identified were population genetics and host plant quality.

4) **Forest Damage Assessment Working Group**
Cochairmen: J.R. Blais (Laurentian Forest Research Centre);
D. Corcoran (Great Northern Paper Co.)

The eight activities from the CANUSA Program Activity Schedule which pertain to damage appraisal were reviewed and conclusions regarding research needs were as follows:

Existing methods for defoliation assessment are adequate, for most needs; however, they should be standardized. .

Mortality appraisal methods are adequate but lack uniformity. Remote sensing techniques need to be compiled and cost appraised.

The possibility of using a decision model was suggested under the topic, "Projecting spruce budworm-caused tree mortality". Also, a handbook prepared specifically for forest managers, giving and explaining known basic rules regarding budworm damage assessment, would be useful.

Regional hazard rating systems, based principally on spruce-fir content of stands, need to be developed for eastern North America.

Site quality, obscured by such features as age, composition and geographic location of the stand, was considered of secondary importance with respect to budworm impact.

Physiological studies are required on the relationships of spruce budworm damage and tree parameters such as stored food and root damage.

Studies are needed on the effect of spruce budworm attack on succeeding stand composition. This could be investigated where damage is known to have occurred in the past.

Finally, the effects of spruce budworm attack on wood fiber quality and tree salvagability should be investigated.

5) **Strategic Population Treatment Working Group**
Cochairmen: Chandra Nigam (Forest Pest Management Institute);
Pat Shea (Pacific Southwest Forest and Range Experiment Station)

Because population treatment research is a very active area, in both Canada and the United States, this was a large group and about 40 reports were given. The meeting was well organized into eight areas as follows:

Immediate research priorities, as visualized by foresters and protection managers, included inte-

grated forest pest management, insecticides of agricultural origin, and insecticide carriers.

Status of registered insecticides and needs for improving efficacy and safety were discussed, including public relations and government-industrial involvement.

Aerial spray application technology included a look at various systems used in spray application, such as guidance, dispersal, and weather monitoring systems. Also there was discussion on characterization of present spray systems in flight, the spray cloud, and studies on micrometeorological effects.

Formulation studies and mobile mixing were discussed. The laboratory screening and other evaluations of compounds, as well as B.t.-chemical combinations were discussed.

Discussion of the biologicals was extensive, and included B.t., viruses, pheromones, IGR's, and fungi (*Entomophthora*).

Sequential sampling of egg masses, defoliation assessment, mode of action of insecticide, and data presentation were the areas described as needing standardization.

Modeling for selection of insecticides included model modifications, involvement of other experts, and inclusion of nonbiological components in models.

Finally the group looked at the liaison of research with various agencies.

6) **Habitat Manipulation, Stand Susceptibility, and Vulnerability Working Group**
Cochairmen: John Dimond (University of Maine at Orono);
Charles Miller (Maritimes Forest Research Centre)

Since many of the studies reported on in other working groups applied to the group, only two formal research reports were presented at this session. D.A. MacLean (MFRC) discussed the use of fire to evaluate and reduce fire hazard in killed stands; and D.A. Perala (NCFES) discussed species conversion and forest susceptibility in the Lake States. It was suggested that the economic feasibility of stand manipulation must be investigated along with the research. Also any silvicultural practices recommended must not lead to other pest problems.

7) **Suboutbreak Population Monitoring Working Group**
Cochairmen: Gary Simmons (Michigan State University);
Lloyd Sippell (Great Lakes Forest Research Centre)

The areas of concern for this working group are insect sampling methods, methods of detecting spruce budworm population outbreak potential, and detecting changes in population density by other than conventional survey methods (e.g. remote sensing).

C.J. Sanders (GLFRC) reported on his development of spruce budworm pheromones as a tool to detect the rate of change in density of low populations as opposed to absolute numbers per unit area. Gary Simmons is analysing data on light trapping in Maine to determine its potential as a population monitoring tool. D.O. Greenbank concludes from his studies in New Brunswick that light traps are useful for monitoring moth movement but it is difficult to get an unbiased sample. Dan Jenning's prototype automated egg mass counter was field tested in Maine this year. There was no significant difference when the machine counts were compared with manual counts. Additional refinements are needed before the machine is fully operational.

8) **Integrated Pest Management Planning and Decision Modeling Working Group**
Cochairmen: C. Shoemaker (Cornell University);
J.C. Mercier (Groupe de Conseil Gestion Forestier (COGEF), Que.)

With an average of 30 people in attendance, 10 scientists representing USDA-FS, Michigan State University, Cornell University, COGEF Quebec, and New Brunswick, gave reports on modeling. D. Solomon (NE) reviewed his tree growth work and pointed out that defoliation affected bole volume growth in both sprayed and unsprayed stands. J.C. Mercier's group detailed the history and operation of a Quebec management model which uses a basic simulation model. C. Shoemaker and R. Shepherd are working on tree-phenology models in the east and west respectively.

It was suggested that managers should be invited to the next working group meeting to detail the information used in making forest management decisions.

EMOFICO Committee Meets In Fredericton

The Environmental Monitoring of Forest Insect Control Operations (EMOFICO) Committee met on February 25, 1980, at the Maritimes Forest Research Centre, Fredericton, N.B. Twenty-one officers from government, industry and university were in attendance to discuss the results of scrutiny of the 1979 N.B. spray operation and plans for the 1980 season. H.J. "Bud" Irving, Manager of Forest Protection Ltd., (FPL) outlined the plans for the 1980 operation. It is predicted that about 4 million acres of forest will be treated to control the spruce budworm in N.B. during the coming year — 3.3 million acres with two applications of fenitrothion at 3 ounces active ingredient (oz.a.i.) per acre and 0.7 million acres with two applications of aminocarb (Matacil[R]) at 1 oz a.i. per acre. The fenitrothion will be applied by TBM Grumman Avenger aircraft and the aminocarb by DC6. The one-mile leave strip, or buffer zone, near human habitation is again in effect for the coming season, although there is considerable pressure from small landowners to be included within the protection program. FPL plans experimental trials using B.t. encompassing 4-10 thousand acres. No trials will be attempted using pheromones.

The Chairman (Bill Varty) tabled a report on the status of studies involving the behavior of spray clouds in terms of long-range, off-target drift. Monitoring plans during 1980 include studies on pesticide accountancy, a conclusion of the studies of effects on white-throated sparrows and red squirrels, the impact of habitat change due to defoliation on wildlife, and continuing studies on terrestrial arthropods. Aquatic studies and study of the effect of large drops are also planned. In 1980, EMOFICO will continue to report through the University of New Brunswick, but the future of the Committee and

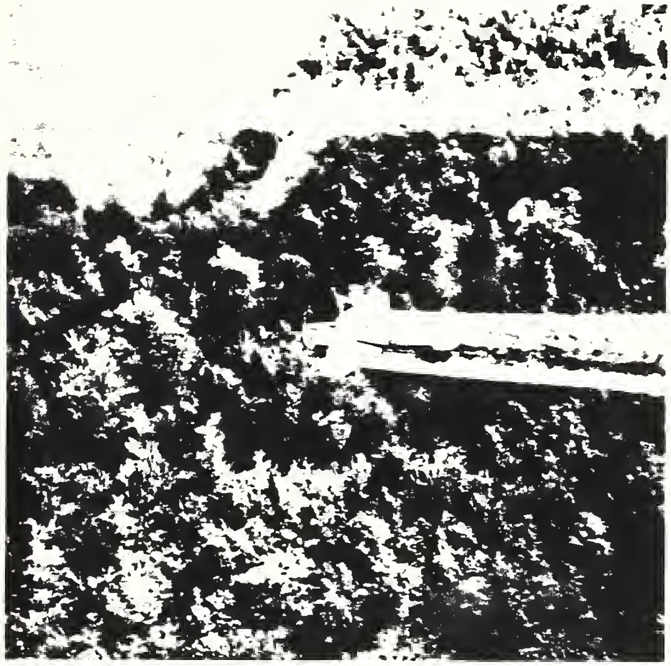

Figure 2 Grumman TBM aircraft spraying fenitrothion over New Brunswick

its leadership is uncertain. Problems facing EMOFICO are lack of funding, reliable methods, interpretation of data, and information transfer to the general public.

Northeastern Forest Pest Council

The NEFPC held its 1980 winter meeting in Portland, Maine, on March 11 and 12. Ed Ketella (MFRC) gave the results of the budworm survey for eastern Canada while Henry Trial (Maine Forestry Service) gave the overview for Maine. Dave Grimble (Applications Coordinator, CANUSA-East), and Bob Taylor (Assistant Program Leader, Canada), gave CANUSA activities updates for the United States and Canadian elements, respectively. There was also a group presentation, led by John Dimond (University of Maine), on the current status of B.t. in forest insect control.

Tree/budworm workshop held in the Twin Cities

An informal workshop on tree/budworm interactions was held at the University of Minnesota, St. Paul, on February 28 and 29. Eighteen participants attended, representing three eastern and three western CANUSA Program-sponsored projects as well as two projects not funded directly by the program. All are investigating the effect of host stands and/or individual trees on budworm feeding, growth reproduction, and survival. Representatives from each project gave informal overviews of their research, which was followed by a question-answer session. This format was highly successful in stimulating vigorous discussion about conceptual approaches, techniques, and interpretation of results.

A consensus emerged that most measures of insect activity usually show only weak relationships to individual or single characteristics of plants or stands. Because insects are adapted and sensitive to a broad ensemble of plant and stand variables, many of which are usually intercorrelated, insect activity should be analyzed in relation to the ensemble of host variables using multivariate techniques. Different researchers were successful, however, in demonstrating significant univariate relationships between insect feeding, growth and body size and dietary levels of sugars, nitrogen, and certain monoterpenes.

Since most projects are either just getting underway or in "mid-stream," no definitive or widely applicable patterns have yet emerged. However, there is great anticipation that some will soon surface to help explain budworm outbreak release and stand susceptibility.

CANUSA — West Canadian Program

The entire CANUSA-West research program of the Canadian Forestry Service (CFS) is conducted through the Pacific Forest Research Centre (PFRC) at Victoria, B.C. The budworm epidemic that began in 1969-70 was recognized as a major threat to the Douglas-fir forests of B.C. by CFS and provincial authorities. The latter, who own the forest and are responsible for its management, fully realize that insect and disease pests dramatically affect forest production and are probably responsible for more than one billion dollars in losses annually to the forests of B.C. Consequently, the spruce budworm research that has developed at PFRC over the past several years, and which is now recognized as the Canadian contribution in the CANUSA-West component, fills an international as well as a local need.

Perhaps it is unfortunate that renewed interest in research on western spruce budworm in B.C. has come when populations have diminished dramatically without any obvious reasons for the collapse. Conjecture, without supportive data, suggests the cause is extrinsic in nature and may have been caused by a lack of synchronization between budworm and bud development over a 2-3 year period. Research on western spruce budworm at PFRC embraces a number of loosely related, yet well coordinated studies. These are designed to make the maximum use of the few resources and expertise available at the Centre. The main thrust of the program is conducted under the leadership of Dr. Roy Shepherd in close cooperation with the USDA Forest Service and has the following objectives:

1) Evaluate the use of virus, B.t. and pheromones as control agents and the impact these have on native parasitoids.
2) Elucidate the role of wind and temperature upon dispersal of western spruce budworm in mountainous situations as measured by the X-ray (XES) system.
3) Develop a method of estimating defoliation from the ground and from aerial photographs and relating it to insect populations.
4) Determine the inter-relationship between bud development and insect emergence and survival.
5) Develop a pre-outbreak population monitoring system using pheromone traps.

Additional work is currently being conducted by Dr. Van Sickle, relating defoliation to growth and survival of trees. Dr. Alan Thompson is also developing a western spruce budworm model that will be aimed at tying these studies to the growth model being developed for use by the B.C. Ministry of Forests; this will provide budworm management strategies compatible with forest management practices in B.C.

All studies are integrated with, and supportive of the CANUSA-West program in the United States. By September 1983, the termination date of the international agreement, a viable Integrated Pest Management (IPM) for western spruce budworms should be available to the resource manager.

Spruce Budworm Conditions In The Maritimes In 1979 And Hazard Rating For 1980

Ed Kettela, MFRC, reports the following budworm conditions for the Maritimes in 1979 and projections for 1980.

Spray Operations in New Brunswick, 1979

Of the 3,956,000 acres (1 602 000 ha) treated, 3,017,000 acres (1 222 000 ha) received one application of aminocarb (Matacil); 59,000 acres (24 000 ha), set aside for research, received two applications of fenitrothion and the remainder, two applications of aminocarb. Although the entire area to be sprayed was to have received two applications of insecticide, unusual weather hampered the operation and forced the modification.

The results of the spray program were generally satisfactory:

1) In general the effectiveness of foliage protection can be rated fair to good with an average of 55 percent of the foliage crop saved;
2) Protection of spruce was significantly better in areas sprayed twice than in those treated once;
3) Results with fenitrothion sprayed twice are similar to those of Matacil sprayed twice;
4) Results in areas sprayed once, although generally acceptable, were more variable both in reduction of population and foliage saved than in areas sprayed twice.

Defoliation in 1979

New Brunswick — Aerial surveys showed that some 3,520,000 acres (1 425 000 ha) of defoliation had been mapped of which approximately 2,680,000 acres (1 085 000 ha) were classified as severe; 580,000 acres (235 000 ha), moderate; and 260,000 acres (105 000 ha), light.

Nova Scotia — Defoliation visible from the air occurred over approximately 2,700,000 acres (1 090 000 ha) of which 2,200,000 acres (890 000 ha) were mapped on Cape Breton Island and the remainder on the mainland. In 1978, the total land area defoliated was approximately 1,900,000 acres (770 000 ha).

Prince Edward Island — The forecasted increase in infestation for 1979 did not materialize, mainly because of excellent tree growing conditions and poor budworm survival. Aerial surveys indicated 90,000 acres (36 400 ha) defoliated (43,700 acres (17 700 ha), severe) in 1979 compared with 300,200 acres (121 500 ha) (210,000 acres (84,900 ha), severe) in 1978. Significantly less severe defoliation was noted in all three counties and was much more patchy and variable than in 1978.

Egg-mass Infestations

New Brunswick — Egg-mass infestations decreased both in areas affected and level of infestations in all areas of the Province except in some sectors of Restigouche, Northumberland, and Kent counties. This decrease is related to the lower level of survival, smaller less prolific adults, and the general lack of adult movement in July. Some 8,800,000 acres (3 600 000 ha) had moderate to severe infestations in 1979 compared with 11,800,000 acres (4 800 000 ha) in 1978.

Nova Scotia — On the mainland, infestations levels increased in Cumberland, Pictou, Kings, and Annapolis counties, and moderate to severe defoliation should be expected in many areas in 1980. Infestation levels decreased in Antigonish and Colchester counties but some patches of high infestations persist.

On Cape Breton Island, on the average, the infestation level increased slightly. By counties, egg-mass counts in 1979 were lower in Cape Breton and Inverness, marginally higher in Richmond, and significantly higher in Victoria. Consequently, further severe defoliation is forecast for most of the softwood forest of Cape Breton Island in 1980. Further, egg-mass infestations were higher on the Highlands that the Lowlands.

Prince Edward Island — There was a significant reduction in egg-mass infestations in 1979 in Prince and Queens counties and a marginal decrease in Kings County. However, high egg-mass counts occurred at Cape Sharp, Murray River, Rollo Bay, and Elmira, Kings County; at Fodhla, Brookdale, and New Glasgow, Queens County; and at Poplar Grove, Cascumpec, Bloomfield, Alberton and Christopher Cross, Prince County; severe defoliation of coniferous stands near these locations is expected in 1980.

Hazard

Hazard is a rating and prediction of risk to the forest in the coming year based on the level of forecasted infestation, defoliation, and tree condition. It is designed to assist in selecting forest areas for protection.

New Brunswick — Of the some 7.7 million acres (3.1 million ha) of hazard delineated in 1979, some 3.7 million acres (1.5 million ha) are in the one mile setback zone and the remainder in the zone of protection. In addition, 1.5 million acres (0.6 million ha) have a high egg-mass infestation, but low hazard for the coming year, so that in total, some 9.2 million acres (3.7 million ha) of New Brunswick warrant some degree of protection in 1980.

Nova Scotia — For Cape Breton Island the hazard rating is generally high to extreme. Balsam fir continued to decline in 1979 as seen in the overall grey, dull green, and red appearance of many stands; the failure of many trees to produce current (1979) shoots; and additional tree mortality. This decline is not confined to the Highlands but is beginning to show on many patches of forest on the Lowlands as well.

On the mainland, sizeable areas of high hazard occur in Cumberland, Colchester, and Pictou counties, but no more than moderate areas of hazard were evident in the Annapolis Valley.

Prince Edward Island — Hazard was rated as moderate to high at many of the sample areas in P.E.I., and reflects the cumulative effect of seven years of spruce budworm feeding. Because of insufficient data on budworm-host interactions for the Island, no detailed hazard map was constructed.

Publications Available

A Special Report, "A Summary of Analytic Expressions for Droplet Evaporation," describes methods for calculating the evaporation rate of spray droplets, a critical factor affecting calculations of pesticide concentration, and the distribution and temporal variation in droplet size. These calculations will enable those working in aerial application to compare data from other experiments without reproducing the tests to evaluate the results. This report is available from the USDA Forest Service, Equipment Development Center, Fort Missoula, Missoula, Montana 59801.

The Canadian Forestry Service offers the following budworm-related reports:

1. G.N. Still 1980. File Reports on spruce and jackpine budworms in Manitoba (Reference File Report NOR-1-033). Northern Forest Research Centre, Canadian Forestry Service, 5320-122 Street, Edmonton, Alberta, T6H 3S5.
2. Compiled by C.J. Sanders. 1980. Summary of Techniques for sampling SBW and estimating defoliation. Inf. Rept. O-X-306. GLFRC, Box 490, Sault Ste. Marie, Ontario, P6A 5M7.
3. Baskerville, G.L. and D.A. MacLean, 1979. Budworm-caused mortality and 20 year recovery in immature balsam fir stands. Inf. Rep. M-X-102. 23 pp. Maritimes Forest Research Centre, P.O. Box 4000, Fredericton, N.B. E3B 5P7.
4. Ostaff, D. Spruce budworm damage on Cape Breton Island and the status of three other troublesome insects. Technical Note No. 5 Maritimes Forest Research Centre, P.O. Box 4000, Fredericton, N.B. E3B 5P7.

Reports available on the western spruce budworm include.

1. James P. Linanne. 1979. Western Spruce Budworm Biological Evaluation. USDA Forest Service, 11177 W. 8th Avenue, Lakewood, Col. 80115.
2. J A E Knopf et al. 1979. Western SBW Populations One Year After Insecticide Treatment. Rpt. 80-1 Methods Application Group, USDA Forest Service, 2810 Chiles Road, Davis, Ca. 95616.

The EMOFICO Committee (reported in this issue) recommended the following reading pertaining to drift and long range transport of insecticides from spray operations.

1. Picot, J.J.C., Kristmanson, D.D., Chitrangad, B. and G Henderson, 1980. Near field drift in aerial spraying. UNB Chem. Eng. 101 pp.
2. Crabb. R., Elias, L., Krzymien, M., and S. Davie, 1980 New Brunswick forestry spray operations: field study of the effect of atmospheric stability on long-range pesticide drift. NRCC, Nat. Aero. Estab., LTR-UA-52 66 pp.

The Quebec Ministry of Energy and Resources has published an interesting report "Pour ou Contre les Arrosages Contre la Tordeuse?" by Louis Dorais and Gilles Gaboury The report addresses several "myths" about budworm control: 1) chemical treatment is not efficacious and perpetuates the outbreak; 2) continued spraying produces a "super-budworm"; 3) chemical insecticides can be replaced by B.t.; and 4) a long-term solution to the budworm can be achieved by converting the [illegible] forest to a forest comprised of nonsusceptible trees. An evaluation of the environmental and human health hazards of widespread use of chemical insecticides is included. The original report is in French. Limited copies of an English translation are available from C.H. Buckner, CFS Headquarters, Ottawa.

The following program publications are also available:

International Directory — A revision of the International Directory of Federal, State, and Provincial Personnel Responsible for Research, Development, and Implementation of Pest Management Programs for the Spruce Budworms in the United States and Canada was sent to everyone on the mailing list for the CANUSA Newsletter. If you or your colleagues need additional copies, please contact Mel McKnight in Washington or Chuck Buckner in Ottawa.

International Inventory — Issue No. 3 of the CANUSA R&D Management Inventory has been distributed to investigators who provided information on their activities, and to Program Management offices in Canada and the United States. This issue contains 308 studies or projects (up from 250 in Issue No. 2 for 1979) representing the work of 294 investigators (up from 240). Each investigator is provided an index which lists the studies being conducted under each activity in the CANUSA Program Activity Schedule, and the names, addresses, and phone numbers of all investigators. Full information on any specific study of interest is available from Program Leaders Buckner or McKnight.

Spruce Budworms Thesaurus

A thesaurus of terms used in spruce budworms R,D&A has been prepared by the School of Forest Resources, University of Maine at Orono. It is intended as a companion to the Spruce Budworms Bibliography. Copies are available through Malcolm Hunter, Life Science and Agriculture Experiment Station. Ask for Miscellaneous Report No. 220.

Spruce Budworms Literature Data Base

Dan Jennings of the USDA Forest Service Northeastern Forest Experiment Station at Orono, Maine, principal investigator for the Literature Data Base Project, and Sue Hacker of the University of Maine, report a recent successful visit to the Maritimes Forest Research Centre (MFRC) at Fredericton. Dan and Sue, with assistance from Barry Barner and Mrs. Marg Cameron, unearthed 300 citations not appearing in the first edition. Furthermore, they feel that they have only scratched the surface; there are hundreds more to be gleaned from the MFRC library. An additional visit is planned in the near future in order to complete the task.

Personnel

MFRC reports that Lloyd J. Coady recently became Ranger Supervisor, Forest Insect and Disease Survey, for Nova Scotia and Prince Edward Island. Lloyd works out of the Truro office and has been with the Survey in Nova Scotia since 1948. Members of the CANUSA Joint Planning Unit (JPU) will remember with thanks the wonderful job Lloyd did in assisting the hosting of the meeting last August on Cape Breton Island.

A rose by any other name. . .

To the surprise of some NEWSLETTER readers "Eastern spruce budworm" is not the common name for *Choristoneura fumiferana*. "Spruce budworm" is the common name approved by the Entomological Society of America (ESA), and thereby recognized by the ESA and the Canadian Entomological Society for use in society publications. This does not preclude the use of the trinomial in other publications and unpublished agency reports — but what about professionalism? Shouldn't all our work reflect the standards of our professional societies?